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Description

LIQUID CRYSTAL ON SILICON DISPLAY

BACKGROUND OF INVENTION

[0001] 1. Field of the Invention

[0002] The invention relates to a liquid crystal on silicon display (LCOS display), and more particularly, to an LCOS display having color filters positioned on the top surface of the cover substrate.

[0003] 2. Description of the Prior Art

[0004] LCOS display technology is the key of reflective LCOS projectors and rear-projection televisions. The advantages of LCOS micro-displays are a tiny size, high resolution, low power, low cost, etc. The difference between an LCOS display and a conventional thin film transistor-liquid crystal display (TFT-LCD) is materials used for forming substrates. Both a cover substrate and a backplane are made of glass in a TFT-LCD. Nevertheless, the cover substrate in an LCOS display is made of glass, but the backplane in an LCOS display is a semiconductor silicon substrate.

Therefore, an LCOS process combines LCD techniques and complementary metal-oxide semiconductor (CMOS) processes.

[0005] The main structure of an LCOS display includes a light source module, an LCOS panel, and a color separation and combination optical system. Generally speaking, the LCOS display can be divided into three-panel LCOS displays and single-panel LCOS displays according to the type of optical engine. The three-panel type optical engine separates lights generated from light source into red, blue, and green lights through a plurality of prisms, projects those lights into three separated LCOS panels respectively, and combines those three lights from LCOS panels to form colored images. The single-panel type optical engine utilizes a color wheel to form red, blue, and green lights sequentially from white lights, and synchronizes the three kinds of lights with single-colored images, the red, blue, and green images, formed by driving programs so as to produce color-separated images sequentially. Since human eyes have the persistence of vision, people can see colored images from the projected images.

[0006] Please refer to Fig.1, which is a schematic diagram of a portion of an LCOS panel 10 according to the prior art.

The LCOS panel 10 comprises a semiconductor substrate 12 with pluralities of MOS transistors and pixel electrodes (not shown) thereon, a glass substrate 14 positioned in parallel with and opposite to the semiconductor substrate 12, a liquid crystal layer 16 positioned between the semiconductor substrate 12 and the glass substrate 14, and a transparent conductive layer 18 positioned on the liquid crystal layer 16. Generally, a conventional LCOS panel 10 comprises an anti-reflective (AR) coating 22 positioned on the glass substrate 14 and two alignment layers (not shown) positioned on the top and bottom sides of the liquid crystal layer 16. The conventional LCOS panel 10 may further comprise a color filter 20 positioned between the transparent conductive layer 18 and the glass substrate 14 or between the alignment layer above the liquid crystal layer 16 and the transparent conductive layer 18.

[0007] However, no matter if the color filter 20 is positioned between the glass substrate 14 and the transparent conductive layer 18, or between the transparent conductive layer 18 and the alignment in the prior art, it causes a disadvantage of heat generated by the color filter 20 when the LCOS panel 10 is operating accumulating in the inner portion of the LCOS panel 10 because the heat cannot be re-

moved by an outer cooling system easily. Consequently, the longevity of the elements of the LCOS panel 10 decreases. Therefore, how to design a structure of the LCOS panel for improving the performance of heat radiation so as to extend the longevity of the elements of the LCOS panel is still an important issue for manufacturers.

SUMMARY OF INVENTION

[0008] It is therefore a primary objective of the claimed invention to provide an LCOS display panel that has a better performance of heat irradiating and lower cost to solve the above-mentioned problem.

[0009] According to the claimed invention, the display panel comprises a silicon substrate having a plurality of pixels arranged in a pixel array thereon, a transparent substrate positioned above the silicon substrate, a liquid crystal layer positioned between the transparent substrate and the silicon substrate, and a plurality of micro color filters positioned on the top surface of the cover substrate, which is a transparent substrate. Each of the pixels on the silicon substrate comprises a plurality of subpixels, and each of the micro color filters is positioned corresponding with one of the subpixels.

[0010] It is an advantage of the claimed invention that the micro

color filters are positioned on the top surface of the transparent substrate, so that heat does not accumulate in the inner portion of the display panel to overheat the display panel that causes damage to the inner elements. Furthermore, the heat generated by the micro color filters positioned on the display panel can be easily removed by an outer cooling system, such as a cooling fan, to maintain a preferable temperature of the display panel. On the other hand, when the micro color filters are positioned on the top surface of the transparent substrate, an AR coating can be substituted so as to decrease the fabricating cost of the display panel.

[0011] These and other objectives of the present invention will no doubt become obvious to those of ordinary skill in the art after having read the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0012] Fig.1 is a section view of a portion of an LCOS panel according to the prior art.

[0013] Fig.2 is a section view of an LCOS panel according to the present invention.

[0014] Fig.3 is a section view of a portion of an LCOS panel of

another embodiment according to the present invention.

Detailed Description

[0015] Please refer to Fig.2. Fig.2 is a section view of an LCOS panel 30 according to the present invention. LCOS panel 30 comprises a silicon substrate 32, a transparent substrate 34 positioned above the silicon substrate 32, and a liquid crystal layer 36 positioned between the silicon substrate 32 and the transparent substrate 34. The silicon substrate 32 has a pixel region 46 thereon and a plurality of MOS transistors and corresponding pixels (not shown) are positioned in the pixel region 46. The transparent substrate 34 has a top surface 34a and bottom surface 34b. On the bottom surface 34b of the transparent substrate 34 is a transparent conductive layer 38, such as an indium tin oxide (ITO) layer. A top alignment layer 42 and a bottom alignment layer 44 are positioned between the liquid crystal layer 36 and the transparent conductive layer 38, and between the liquid crystal layer 36 and the silicon substrate 32 respectively for adjusting the arrangement directions of the liquid crystal molecules in the liquid crystal layer 36. In this embodiment, the transparent substrate 34 is a glass substrate. However, the transparent substrate 34 can also be composed of other trans-

parent materials, such as quartz.

[0016] The LCOS panel 30 further comprises a color filter 40 positioned on the top surface 34a of the transparent substrate 34 and corresponding with the pixel region 46. The color filter 40 can be composed of a photosensitive material, such as a photoresist material or a photosensitive resin. In addition, the photosensitive material further contains red, blue, or green dyes so that the LCOS panel 30 can reflect lights with a specific color.

[0017] In this embodiment, the LCOS panel 30 can be applied to a three-panel LCOS display. That can be performed by positioning three LCOS panels 30 with a red color filter, a blue color filter, and a green color filter respectively in the three-panel LCOS display, and using a combination optical system to combine the red, blue, and green images from the three LCOS panels 30 to form complete and colorful images.

[0018] Referring to Fig.3, which is a section view of a portion of an LCOS panel 50 of another embodiment according to the present invention. The present invention LCOS display has an LCOS panel 50 comprising a silicon substrate 58, a glass substrate 56, and a liquid crystal layer 62 positioned between the silicon substrate 58 and the glass substrate

56. An ITO layer 60, serving as the transparent conductive layer, is positioned between the glass substrate 56 and on its bottom surface 56b. The LCOS panel 50 further comprises a top alignment layer 64 positioned above the liquid crystal layer 62 and below the ITO layer 60. The silicon substrate 58 is a semiconductor substrate having a plurality of pixels arranged in a pixel array. Each of the pixels further comprises three subpixels. In Fig.3, only one pixel 52 and its subpixels 54a, 54b, 54c are illustrated. Each of the subpixels 54a, 54b, 54c contains a MOS transistor and a metal electrode (not shown) for controlling the corresponding subpixels 54a, 54b, 54c so that the liquid crystal molecules in the liquid crystal layer 62 twist to let light pass through the liquid crystal layer 62. Furthermore, a bottom alignment layer 66 is positioned on the silicon substrate 58.

[0019] The LCOS panel 50 further comprises a plurality of micro color filters, the red micro color filters 68a, the blue micro color filters 68b, and the green micro color filters 68c corresponding with one of the subpixels 54a, 54b, 54c of each of the pixels 52. Each of the red micro color filters 68a, the blue micro color filters 68b, and the green micro color filters 68c is composed of pluralities of stacked op-

tical thin films that forms a low index optical thin-film stack comprising a silicon oxide (SiO_2) thin film or forms a high index optical thin-film stack comprising a titanium oxide (TiO_2) thin film or a tantalum oxide (Ta_2O_5) thin film. In this embodiment, the optical thin films forming micro color filters are dichroic films.

[0020] The micro color filters are used for filtering lights of specific spectrums. The red micro color filters 68a, blue micro color filters 68b, and green micro color filters 68c shown in Fig.3 only permit lights of a first specific spectrum, a second specific spectrum, and a third specific spectrum to pass respectively. In a preferred embodiment of the present invention, the lights of the first specific spectrum, the second specific spectrum, and the third specific spectrum are red, green, and blue lights respectively. In addition, the red micro color filters 68a, blue micro color filters 68, and green micro color filters 68c are positioned corresponding with the metal electrodes of the subpixels 54a, 54b, 54c on the surface of the silicon substrate 58 respectively. Therefore, the lights passing through the red micro color filters 68a, the blue micro color filters 68b, and the green micro color filters 68c can be reflected by the under metal electrodes and hence the

reflected lights of different spectrums mix to form colorful images.

[0021] In another embodiment of the present invention, the red micro color filters 68a, the blue micro color filters 68b, and the green micro color filters 68c are composed of photosensitive materials, such as photoresist materials or photosensitive resins, containing red, blue, or green dyes to filter white lights passing through the micro color filters. Similarly, the filtered red lights, blue lights, and green lights can be reflected to form colorful images.

[0022] Furthermore, opaque layers (not shown) can be optically coated among the red micro color filters 68a, blue micro color filters 68b, and green micro color filters 68c to reduce interferences between different color lights and improve the signal to noise ratio, leading to an enhanced display performance. The materials of the opaque layers can be selected from any one of Al, Cr, Ni, Cu, Fe, Zn, Ti, Au, Ag, Pt, W, Mo, Ta, Zr, C or mixtures of them.

[0023] The present invention LCOS panel 50 can be applied to a single-panel LCOS display. Since the LCOS panel 50 can produce color images directly through the red micro color filters 68a, blue micro color filters 68b, and the green micro color filters 68c, no complicated optical engines, such

as a color wheel or a color separation and combination optical system, have to be installed in the LCOS display. Therefore the fabricating cost can be decreased effectively, and the physical volume of the LCOS display can also be reduced so as to satisfy the requirement of the LCOS display market.

[0024] In contrast to the prior art, the present invention provides a display panel that has color filters composed of optical thin-film stacks or photosensitive materials positioned on the cover substrate, the transparent substrate. Consequently, the problem of the prior art in which heat accumulates in the inner portion of the LCOS panel resulting in overheating of the LCOS panel can be solved. Since the color filters are positioned on the surface of the LCOS panel, the heat generated by the color filters when the LCOS is operating can be removed easily by a cooling system positioned near the LCOS panel. For example, a cooling fan can be positioned near the LCOS panel to reduce the temperature of the color filters so that the surface of the LCOS panel is cooled to maintain a preferable temperature. On the other hand, to position the color filters on the surface of the transparent substrate of the LCOS panel, an AR coating of the conventional LCOS panel can

be substituted to lower the cost to LCOS panel manufacturers.

[0025] Those skilled in the art will readily observe that numerous modifications and alterations of the device may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.